AMENDMENTS TO THE DRAWINGS

Attachments: Annotated Sheet (1)
Replacement Sheet (1)

REMARKS

This Amendment is filed in response to the non-final Office Action dated May 1, 2009, and is respectfully submitted to be fully responsive to the rejections raised therein. Accordingly, favorable reconsideration on the merits and allowance are respectfully requested.

In the present Amendment, Fig. 3 has been amended to correct a reference character. The corrected drawing sheet (1), entitled "Replacement Sheet" is in compliance with 37 C.F.R. § 1.121(d).

The specification has been amended to reflect the changes to Fig. 3. Namely, the specification was amended to change the phrase "a heater 11" to "a heater 13".

Claim 1 was amended to recite a self-washing step of rotating said elastic polishing member, in a position spaced from a position which said washing step is conducted in, supplying the same liquid as a liquid used in said washing step to said elastic polishing member, and, in this condition, deforming said elastic polishing member so as thereby to wash said elastic polishing member. Support for the amendment to claim 1 can be found in the specification on page 8, lines 8-17 and in the paragraph bridging pages 31 and 32, for example.

No new matter has been added. Entry of the Amendment is respectfully submitted to be proper. Upon entry of the Amendment, claims 1-15 will be all the claims pending in the application.

I. Information Disclosure Statement

The Examiner asserts that the Information Disclosure Statement filed April 19, 2005 fails to comply with 37 C.F.R. § 1.98(a)(2), and therefore the references cited therein were placed in the application file and have not been considered.

The references that were not considered are the last five (5) references listed on the SB/08 form submitted with the Information Disclosure Statement dated April 19, 2005. These references were listed in an International Search Report (ISR). At the time of filing, Applicants did not provide these references to the U. S. Patent and Trademark Office because historically, the International Bureau (IB) supplied the Office with the references listed in an ISR. Since the IB no longer provides such service, Applicants concurrently submit herewith a copy of EP 764478 and abstracts for JP 6-312163, JP 2003-146667, JP 5-269757 and JP 8-258171. Consideration of these references is respectfully requested (if a fee is needed for consideration of the references, please charge it to Deposit Account 19-4880).

II. Response to the Objection to the Drawings

The drawings in the preset application are objected to as failing to comply with 37 C.F.R. § 1.84(p)(4) because, per the Examiner, the reference character "11" has been used to designate both a convex surface in Fig. 2 and a heater in Fig. 3.

Applicants respectfully request that the objection be withdrawn in view of the amendments to the drawings attached herewith. Particularly, Fig. 3 has been amended to correct the above-mentioned reference character; i.e., reference number 11 has been changed to number 13. (*See* Annotated Sheet). Applicants submit that the corrected drawing sheet (1), entitled "Replacement Sheet", is now in compliance with 37 C.F.R. § 1.121(d).

III. Response to Rejection Under 35 U.S.C. § 103(a)

Claims 1-5 are rejected under 35 U.S.C. § 103(a) as being unpatentable over JP 2001-353650[2] to Tabata (JP '650) in view of JP S64-23224 to Murakami (JP '224). The Examiner asserts that it would be obvious to one of ordinary skill in the art to modify the method taught by Tabata to include a self-washing step as taught by Murakami to remove contamination, which then adheres to the surface of the cleaning apparatus. According to the Examiner, the motivation to modify the invention in Tabata to add a self-washing step is derived from the desire to reduce the effect of having a contaminated surface which may cause scratches on the surface to be cleaned.

Applicants respectfully traverse the rejection and request that the rejection be withdrawn in view of the Amendments to the Claims and the following remarks.

Applicants submit that the presently claimed invention is directed to a scrubbing method wherein it is possible to wash a lens mold without leaving dirt on the lens mold and without marring the lens mold. If dirt or foreign matter is present on the lens molds, the dirt or the foreign matter would be transferred onto the plastic optical lens obtained by the mold, which would thereby yield or exert bad effects on the optical surfaces produced. Completely removing this dirt or foreign matter is necessary, and therefore, in the presently claimed invention, the molding surfaces of the lens molds are subjected to precise washing.

The presently claimed invention, recites a scrubbing method comprising: a washing step of rotating a lens mold for molding a plastic lens, pressing an elastic polishing member against a

[2] References made to JP 2001-353650 to Tabata are based on the machine translation of JP '650 as provided with the Office Action dated May 1, 2009.

surface of said lens mold while rotating said elastic polishing member, and, in this condition, supplying a liquid to the area between said surface of said lens mold and said elastic polishing member so as thereby to wash said lens mold; and a self-washing step of rotating said elastic polishing member, in a position spaced from a position which said washing step is conducted in, supplying the same liquid as a liquid used in said washing step to said elastic polishing member, and, in this condition, deforming said elastic polishing member so as thereby to wash said elastic polishing member.

Thus, in the self-washing step, the same liquid that is supplied to/used in the washing step is the same liquid used in the self-washing step. Furthermore, the washing step and the self-washing step can be conducted alternately at short times thereby effective washing of a lens mold for molding a plastic lens can be conducted.

Tabata does not disclose a self-washing step and is therefore deficient with respect to the presently claimed method steps. The Examiner concedes to this point.

Applicants submit that Murakami fails to cure the deficiencies in Tabata.

Murakami discloses a cleaning brush apparatus having a brush body that is formed of a soft material and attached around a rotation shaft, wherein the front end portion of the brush body is pressed for cleaning against a surface to be cleaned. Murakami teaches that a rotational cleaning brush is generally used as a cleaning device for aircrafts, automobiles, railway vehicles and the like.

However, Murakami fails to disclose or suggest a self-washing step in a position spaced from a position which a washing step is conducted in, wherein the same liquid as the liquid used in the washing step is supplied. Murakami therefore fails to cure the deficiency of Tabata

because Murakami does not teach a self-washing according to amended claim 1. Accordingly, Applicants request that the rejection of claims 1-5 be withdrawn.

IV. Conclusion

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,

/Nyeemah A. Grazier/

Nyeemah A. Grazier
Registration No. 63,657

SUGHRUE MION, PLLC
Telephone: (202) 293-7060
Facsimile: (202) 293-7860

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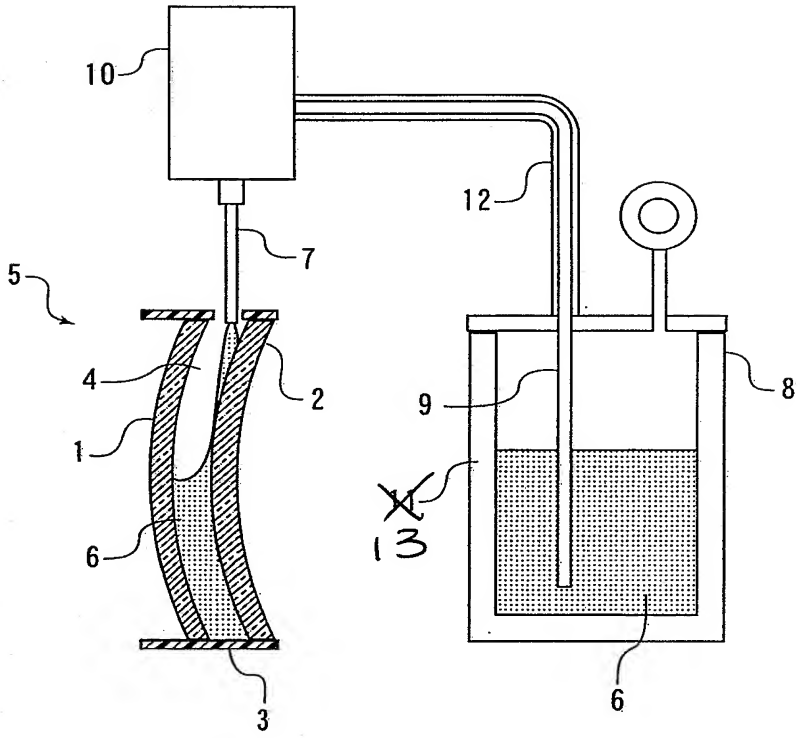
Date: August 3, 2009

Fig. 3



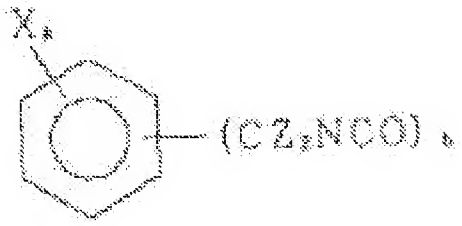
No title available

Publication number: JP5269757 (A)
Publication date: 1993-10-19
Inventor(s):
Applicant(s):
Classification:
- international: ***B29C39/02; C08G18/04; C08G18/67; G02B1/04;*** *B29K75/00; B29L11/00;* **B29C39/02; C08G18/00; G02B1/04;** (IPC1-7): B29C39/02; C08G18/04; C08G18/67; G02B1/04; B29K75/00; B29L11/00
- European:
Application number: JP19920017587 19920203
Priority number(s): JP19920017587 19920203

Also published as:
JP6061768 (B)
JP1941340 (C)

Abstract of **JP 5269757 (A)**

PURPOSE: To provide a lens excellent in workability, impact resistance, solvent resistance, etc., and having good transparency, hardness and high refractive index by carrying out an casting polymerization after mixing and compositing a specified monomer compound represented by a specified and generalized formula with other specified monomer represented by a specified and generalized formula. CONSTITUTION: A plastic lens is formed by casting polymerization after mixing and compositing at least one monomer compound selected from benzene ring containing polyisocyanate represented by formula I with at least one monomer compound selected from allyl group containing compounds represented by formula II. Here in formula I, X represents hydrogen, chlorine, bromine, methyl group or ethyl group, and Z represents hydrogen or methyl group. a and b satisfy 2<=b<=4, 1<=a<=4, and a+b<=6.; In formula II, R1 represents phenol group and hydroxyl group or amino group.



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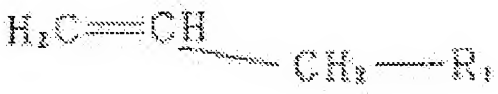


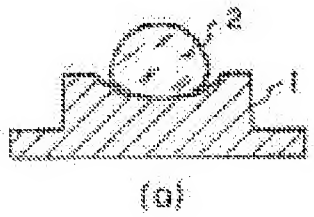
II

MOLD CLEANING METHOD

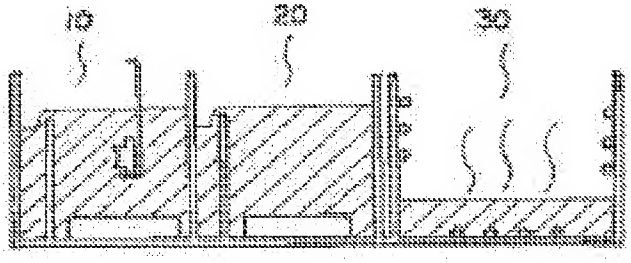
Publication number: JP6312163 (A)
Publication date: 1994-11-08
Inventor(s): KUWABARA TETSUO; YOKOTA MASAAKI; NAKAI YASUYUKI
Applicant(s): CANON KK
Classification:
- international: ***B08B3/12; B29C33/72;*** *B29C33/72;* **B08B3/12; B29C33/70;** B29C33/70; (IPC1-7): B29C33/72; B08B3/12
- European:
Application number: JP19930122080 19930427
Priority number(s): JP19930122080 19930427

Abstract of **JP 6312163 (A)**

PURPOSE:To provide a mold cleaning method to remove adhering substances which adhere to molds of glass gob by a means comprising immersing the molds in warm water to which ultrasonic vibration is applied, showering warm water, spraying steam, etc.
CONSTITUTION:In a mold cleaning method to remove substances adhering to the molding face of a mold 1 of glass gob 2, the molding face of the mold is cleaned by immersing the mold 1 in warm water which is vibrated by ultrasonic waves for a prescribed period or showering warm water to the mold or hitting steam to the molding face of the mold.



(a)



(b)

MANUFACTURE OF PLASTIC LENS

Publication number: JP8258171 (A)
Publication date: 1996-10-08
Inventor(s): FUKUSHIMA HIROSHI; MOTONAGA AKIRA; MORITA MITSUHARU; MAKINO SHINJI
Applicant(s): MITSUBISHI RAYON CO
Classification:
- international: ***G02C7/02; B29C35/02; B29C39/02; B29C69/00; B29D11/00; C08F2/46; C08F2/54; G02B1/04;*** *B29L11/00;* **G02C7/02; B29C35/02; B29C39/02; B29C69/00; B29D11/00; C08F2/46; G02B1/04;** (IPC1-7): B29D11/00; B29C35/02; B29C39/02; B29C69/00; C08F2/46; G02B1/04; G02C7/02; B29L11/00
- European:
Application number: JP19950068392 19950327
Priority number(s): JP19950068392 19950327

Abstract of **JP 8258171 (A)**

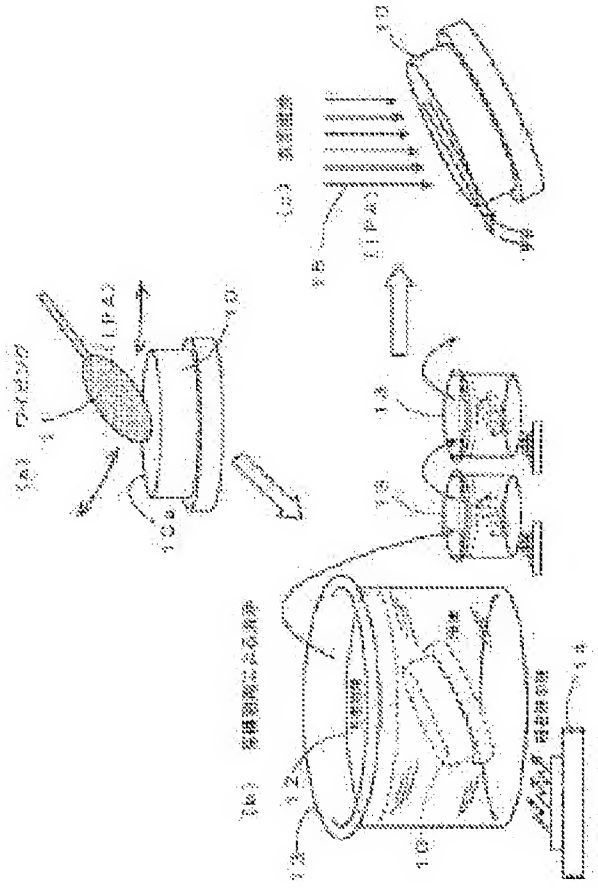
PURPOSE: To manufacture a lens of excellent transparency, resistances to impact, heat, and the like by casting a liquid composition containing a monomer of radical polymerization properties or oligomer and an active energy radiation- sensitive and heat-sensitive radical polymerization initiator at the specified weight ratio, partially polymerized by the emission of active energy radiation and then heating. CONSTITUTION: A liquid composition containing an active energy radiation- sensitive radical polymerization initiator of 0.005-5 pts.wt. and heat-sensitive radical polymerization initiator of 0.005-5 pts.wt. is cast to at least one kind of a radical polymerization monomer or oligomer of 100 pts.wt. Then the liquid composition is polymerized partially by the emission of active energy radiation, and successively polymerized by heating to cure the liquid composition. A compound having (meth)acryloyl of 60 pts.wt. or more is used as a functional group of radical polymerization properties in the liquid composition. The active energy radiation-sensitive radical polymerization initiator is functioned to active energy radiation such as ultraviolet rays to generate a radical source.

METHOD OF PRODUCING DIE FOR MOLDING, AND PRODUCTION APPARATUS THEREFOR

Publication number: JP2003146667 (A)
Publication date: 2003-05-21
Inventor(s): ASAI HIROKI; ITO KENTA; TSUJI HIROYASU; NAKAJIMA NORIHIKO; OKABE AKIHIKO
Applicant(s): MATSUSHITA ELECTRIC IND CO LTD; FUJI ELECTRIC CO LTD
Classification:
- international: ***C03B11/00; C03B11/08; G11B5/84;*** **C03B11/00; C03B11/06; G11B5/84;** (IPC1-7): C03B11/00; G11B5/84
- European: C03B11/08D
Application number: JP20010350025 20011115
Priority number(s): JP20010350025 20011115

Abstract of **JP 2003146667 (A)**

PROBLEM TO BE SOLVED: To solve the problem that, in a glass substrate of an information recording medium, as for the surface precision of a die for molding thereof, hyperfine foreign matters of several 10 nm height cause troubles to the high recording densification of current information recording medium. SOLUTION: With a die base material 10 after surface polishing as an object, in a first stage, the die base material 10 is immersed into an organic solvent 12, and is cleaned. In a second stage, an oily/aqueous surface substitution agent flowing system 15 is started to the die base material 10. In a third stage, a scrub cleaning system 20 is started to the die base material 10, and scrub cleaning using a surfactant-containing cleaning agent is performed. If required, its immersion in a surfactant-containing cleaning agent 24 is performed before or after the scrub cleaning.



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(11) EP 0 764 478 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
26.03.1997 Bulletin 1997/13

(51) Int. Cl.[6]: **B08B 1/04**

(21) Application number: **96115046.3**

(22) Date of filing: **19.09.1996**

(84) Designated Contracting States:
DE FR

(30) Priority: **20.09.1995 JP 266395/95**

(71) Applicants:
- **EBARA CORPORATION**
  Ohta-ku, Tokyo (JP)
- **KABUSHIKI KAISHA TOSHIBA**
  Kanagawa-ken 210 (JP)

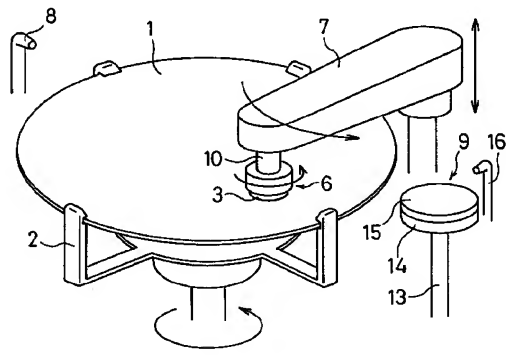
(72) Inventors:
- **Maekawa, Tashiro**
  Sagamihara-shi, Kanagawa-ken (JP)
- **Hamada, Satomi**
  Fujisawa-shi, Kanagawa-ken (JP)
- **Ono, Koji**
  Fujisawa-shi, Kanagawa-ken (JP)
- **Shigeta, Atsushi**
  Fujisawa-shi, Kanagawa-ken (JP)
- **Kodera, Masako**
  Yokohama-shi, Kanagawa-ken (JP)

(74) Representative: **Geyer, Ulrich F., Dr. Dipl.-Phys. et al**
WAGNER & GEYER,
Patentanwälte,
Gewürzmühlstrasse 5
80538 München (DE)

(54) Method of and apparatus for cleaning workpiece

(57) A method of and an apparatus for cleaning workpiece is suitable for cleaning a substrate such as a semiconductor substrate, a glass substrate, or a liquid crystal panel to a high level of cleanliness. The method of cleaning a workpiece comprises the steps of holding a workpiece (1), scrubbing the workpiece with a cleaning member (3), and rubbing the cleaning member (3) against a member (15) having a rough surface to carry out a self-cleaning of the cleaning member (3). The cleaning member (3) which is contaminated by having scrubbed the workpiece (1) is rubbed against the rough surface (15b), and the rough surface (15b) scrapes the contaminant off the cleaning member (3). Therefore, the contaminant can effectively be removed from the cleaning member (3), and hence the cleaning member (3) has a high self-cleaning effect.

FIG. 1



EP 0 764 478 A1

Description

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a method of and an apparatus for cleaning a workpiece, and more particularly to a method of and an apparatus for cleaning a substrate such as a semiconductor substrate, a glass substrate, or a liquid crystal panel to a high level of cleanliness.

Description of the Prior Art:

As semiconductor devices become more highly integrated in recent years, circuit interconnections become thinner and the distances between those interconnections also become smaller. While processing a semiconductor substrate, particles such as minute semiconductor particles, dust particles, or small crystalline pieces tend to be attached to the semiconductor substrate. If particles existing on the semiconductor substrate are greater in size than the distances between interconnections on the semiconductor substrate, then short-circuits will possibly be developed between the interconnections. To avoid such a drawback, any particles present on the semiconductor substrate are required to be sufficiently smaller than the distances between interconnections on the semiconductor substrate. This holds true for the processing of other substrates including a glass substrate for use as a photomask, a liquid crystal panel, etc. To meet such a requirement, there has been demands for a cleaning process capable of removing smaller particles in the submicron level from semiconductor substrates and other substrates.

It has heretofore been customary to clean a semiconductor substrate by scrubbing it with a cleaning member made of a brush or a sponge.

Research efforts have been made to find a cleaning member which can exhibit a cleaning effect better than the brush or the sponge. As a result, it has been found that an abrasive cloth, used in recent years to polish the surface of a semiconductor wafer to planarize the same in its fabrication process, is effective to clean a workpiece, as proposed in Japanese patent application No. 7-129588 (corresponding to US Patent application No. 08/434,754).

In scrubbing a workpiece with a cleaning member such as a brush, a sponge, or an abrasive cloth, since the cleaning member is held in direct contact with the workpiece, the cleaning effect of the cleaning member depends on the contamination of the cleaning member. Specifically, as the contamination of the cleaning member which is contaminated by the contaminant removed from the workpiece progresses, the contaminant deposited on the cleaning member contaminates the workpiece again, thus lowering the cleaning effect which the cleaning member has. Such a phenomenon is referred to as a reverse contamination. The cleaning member has to be replaced with a fresh cleaning member before the cleaning member causes the reverse contamination.

Replacing the cleaning member with a fresh cleaning member requires the cleaning apparatus to be shut off. Consequently, the processing capability of the cleaning apparatus is lowered, and dust particles produced in a cleaning environment by the replacement of the cleaning member poses problems.

It is desirable to purify the cleaning member without replacing the same when it is contaminated. Such a purifying process is known as a self-cleaning process. According to the conventional self-cleaning processes, it has heretofore been customary to rinse the cleaning member in a cleaning liquid or apply a water jet or an ultrasonically vibrated water stream to the cleaning member.

Inasmuch as the self-cleaning of the cleaning member governs the cleaning effect thereof, prolongs a service life of the cleaning member, and increases the processing capability of the cleaning apparatus, there have been demands for more effective self-cleaning processes.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a method of and an apparatus for cleaning a workpiece with a cleaning member which is cleaned by a self-cleaning of the cleaning member to a high level of cleanliness for thereby increasing the cleaning effect thereof, prolonging the service life thereof, and the processing capability of the cleaning apparatus.

According to an aspect of the present invention, there is provided a method of cleaning a workpiece, comprising the steps of: holding a workpiece; scrubbing the workpiece with a cleaning member; and rubbing the cleaning member against a member having a rough surface to carry out a self-cleaning of the cleaning member.

According to another aspect of the present invention, there is provided a method of cleaning a workpiece, comprising the steps of: holding a workpiece; scrubbing the workpiece with a cleaning member made of an abrasive cloth; and bringing the cleaning member into contact with a brush to carry out a self-cleaning of the cleaning member.

According to another aspect of the present invention, there is also provided an apparatus for cleaning a workpiece, comprising: a holding unit for holding a workpiece; a cleaning unit movable relatively to the workpiece; a cleaning member provided on said cleaning unit for scrubbing the workpiece; and a flat portion having a rough surface for contacting said cleaning member to carry out a self-cleaning of the cleaning member.

According to the present invention, the cleaning member which is contaminated by having scrubbed the

workpiece is rubbed against the rough surface, and the rough surface scrapes the contaminant off the cleaning member. Therefore, the contaminant can effectively be removed from the cleaning member, and hence the cleaning member has a high self-cleaning effect. Inasmuch as the cleaning member is rubbed against the rough surface, a fresh cleaning surface is created on the cleaning member.

If the cleaning member comprises a sponge, the cleaning member is pressed against a flat portion until the cleaning member is elastically deformed. Consequently, the contaminant attached to the cleaning member is squeezed out of the cleaning member together with the cleaning liquid absorbed by the cleaning member.

If the cleaning member comprises an abrasive cloth, it is cleaned by a brush. Since the contaminant, particularly particles, on the cleaning member are directly scraped by the brush, the contaminant can effectively be removed from the cleaning member, and hence the cleaning member has a high self-cleaning effect.

Because the cleaning member which is contaminated by having scrubbed the workpiece is cleaned to a high level of cleanliness by carrying out a self-cleaning of the cleaning member, the cleaning effect of the cleaning member is increased. The cleaning member has an increased service life, and the processing capability of the cleaning apparatus is increased.

The above and other objects, features, and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings which illustrate preferred embodiments of the present invention by way of example.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a cleaning apparatus according to a first embodiment of the present invention, for carrying out a cleaning method according to the present invention;

FIG. 2 is a vertical cross-sectional view of a cleaning unit of the cleaning apparatus shown in FIG. 1;

FIG. 3 is a vertical elevational view of a self-cleaning unit of the cleaning apparatus shown in FIG. 1;

FIG. 4 is a vertical elevational view, partly in cross section, of another self-cleaning unit which can be used in the cleaning apparatus shown in FIG. 1;

FIG. 5 is a perspective view of a cleaning apparatus according to a second embodiment of the present invention, for carrying out the cleaning method according to the present invention;

FIG. 6 is a cross-sectional view showing the positional relationship between a cleaning member and a quartz plate in a cleaning cup of the cleaning apparatus shown in FIG. 5;

FIG. 7 is an enlarged fragmentary perspective view of a surface of the quartz plate;

FIG. 8 is a vertical elevational view of still another self-cleaning unit which can be used in the cleaning apparatus shown in FIG. 1;

FIG. 9 is a perspective view of a system composed of cleaning apparatus according to the present invention which are combined with a polishing apparatus for polishing semiconductor sustrates; and

FIG. 10 is a vertical cross-sectional view of the polishing apparatus shown in FIG. 9.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A cleaning apparatus according to a first embodiment of the present invention will be described below with reference to FIGS. 1 through 3.

As shown in FIG. 1, the cleaning apparatus includes a spin chuck 2 for holding a semiconductor substrate 1, a rotatable cleaning unit 6 having a cleaning member 3 attached to a lower surface thereof, and a vertically and horizontally movable swing arm 7 which supports the rotatable cleaning unit 6 on its distal end in overhanging relation to the semiconductor substrate 1 held by the spin chuck 2. The cleaning apparatus further includes a cleaning liquid nozzle 8 for ejecting a cleaning liquid onto an upper surface, to be cleaned, of the semiconductor substrate 1, and a self-cleaning unit 9 for carrying out a self-cleaning of the cleaning unit 6. The spin chuck 2 is rotatable in a horizontal plane at a predetermined speed, and the cleaning member 3 is made of polyurethane foam having micropores therein. The cleaning unit 6 is supported on the distal end of the swing arm 7 by a vertical shaft 10 extending downwardly from the distal end of the swing arm 7. The cleaning unit 6 can be rotated at a given speed by the shaft 10.

The semiconductor substrate 1 which is to be cleaned by the cleaning apparatus is transferred to a position over the spin chuck 2 by a robot arm or the like, and held by the spin chuck 2 with its surface, to be cleaned, facing upwardly. The semiconductor substrate 1 held by the spin chuck 2 is rotated at a predetermined speed, and simultaneously a cleaning liquid is ejected from the cleaning liquid nozzle 8 toward a substantially central area of the semiconductor substrate 1.

The swing arm 7 is lifted to raise the cleaning unit 6 from the self-cleaning unit 9, and then swung horizontally to move the cleaning unit 6 to a position where the cleaning unit 6 is located above a substantially central area of the semiconductor substrate 1. At this time, the cleaning unit 6 is not rotated. Then, the swing arm 7 is lowered to bring the cleaning unit 6 into contact with the semiconductor substrate 1. Immediately before the cleaning unit 6 contacts the semiconductor substrate 1, the cleaning unit 6 starts being rotated at a given speed by the shaft 10 about the axis thereof.

The cleaning member 3 of the cleaning unit 6, which is being independently rotated in contact with the

upper surface of the semiconductor substrate 1 which is supported and rotated by the spin chuck 2, is pressed against the semiconductor substrate 1 by the swing arm 7. The swing arm 7 is swung at a given speed to an outer circumferential edge of the semiconductor substrate 1 to cause the cleaning member 3 to scrub the semiconductor substrate 1.

If the semiconductor substrate 1 is rotated at a constant speed, the peripheral speed of the semiconductor substrate 1 at the central area thereof differs from the peripheral speed of the semiconductor substrate 1 at the outer circumferential area thereof. Therefore, if the swing arm 7 is swung at a constant speed, then the cleaning member 3 contacts the semiconductor substrate 1 at different rates in different positions on the semiconductor substrate 1, resulting in irregular cleaning effects. Therefore, the speed at which the swing arm 7 is swung or the speed at which the semiconductor substrate 1 rotates should be controlled to allow the cleaning member 3 to scrub the semiconductor substrate 1 uniformly over its entire upper surface.

When the cleaning member 3 reaches the outer circumferential edge of the semiconductor substrate 1, the swing arm 7 is stopped in its horizontal swinging motion, and then lifted to move the cleaning member 3 away from the upper surface of the semiconductor substrate 1. Then, the swing arm 7 is swung back to the central area of the semiconductor substrate 1 for repeating the above cleaning cycle. After the above cleaning cycle is carried out at least once, the supply of the cleaning liquid from the cleaning liquid nozzle 8 is stopped, and the swing arm 7 is swung to the self-cleaning unit 9. The cleaning unit 6 is then lowered onto the self-cleaning unit 9 for self-cleaning.

If the semiconductor substrate 1 is to be dried after it is cleaned, the spin chuck 2 is rotated at a high speed to dry the semiconductor substrate 1 in a spinning action. For cleaning the semiconductor substrate 1 in a next process, at the same time when the supply of the cleaning liquid from the cleaning liquid nozzle 8 is stopped, the rotation of the semiconductor substrate 1 is also stopped, and the semiconductor substrate 1 is transferred to the next process in such a state that the upper surface of the semiconductor substrate 1 is not dried.

FIG. 2 shows in cross section the cleaning unit 6 of the cleaning apparatus shown in FIG. 1. As shown in FIG. 2, the cleaning unit 6 is mounted on the lower end of the shaft 10. The cleaning unit 6 comprises a cartridge 11 and the cleaning member 3 which is attached to a lower surface of the cartridge 11. The cleaning member 3 comprises an abrasive cloth for polishing the semiconductor substrate 1. The abrasive cloth is cut to such a suitable size as to be attached to the lower surface of the cartridge 11. Since the abrasive cloth for polishing the semiconductor substrate 1 has an adhesive layer on its reverse side, the cleaning member 3 can be attached to the lower surface of the cartridge 11 by the use of the adhesive layer. The cartridge 11 and the lower end of the shaft 10 are held in contact with each other through spherical surfaces which allow the cleaning member 3 to be held in uniform contact with the semiconductor substrate 1 even when the semiconductor substrate 1 is tilted with respect to the horizontal plane.

The shaft 10 comprises an upper shaft member 10A and a lower shaft member 10B which are coupled to each other with a helical compression spring 12 interposed therebetween. The helical compression spring 12 serves to dampen forces applied to the semiconductor substrate 1 when the cleaning unit 6 is in contact with the semiconductor substrate 1. Therefore, the cleaning surface of the cleaning member 3 can be kept in contact with the upper surface of the semiconductor substrate 1 under substantially constant pressure. Because of the helical compression spring 12, the semiconductor substrate 1 is prevented from being damaged under excessive forces applied from the cleaning unit 6 to the semiconductor substrate 1 even when the semiconductor substrate 1 is tilted.

The cleaning member 3 has micropores defined in the polyurethane foam of the abrasive cloth, and the micropores are present at least in its surface for contact with the semiconductor substrate 1. While the micropores may be available in various sizes, those micropores which have an average diameter ranging from 10 to 200 μm are suitable for use in the cleaning member 3. When the cleaning member 3 is pressed against the semiconductor substrate 1 and the cleaning member 3 and the semiconductor substrate 1 are moved relatively to each other, particles on the semiconductor substrate 1 are scraped off by edges of the micropores of the cleaning member 3, trapped in the micropores, and removed from the semiconductor substrate 1.

FIG. 3 shows in vertical elevation the self-cleaning unit 9 for carrying out a self-cleaning of the cleaning member 3.

As shown in FIG. 1, the self-cleaning unit 9 is positioned on the path of angular movement of the cleaning unit 6. The self-cleaning unit 9 comprises a flat plate 14 supported on the upper end of a support shaft 13, a dressing member 15 attached to an upper surface of the flat plate 14, and a cleaning liquid nozzle 16 for supplying water onto the dressing member 15. The dressing member 15 comprises a base plate 15a mounted on the flat plate 14 and a layer 15b made of diamond pellets electrodeposited on an upper surface of the base plate 15a. Therefore, the dressing member 15 has an irregular upper surface by the diamond pellets.

After having cleaned the semiconductor substrate 1, the cleaning unit 6 is moved to the self-cleaning unit 9, and presses the cleaning member 3 against the dressing member 15 under a predetermined pressure. The swing arm 7 is swung and the cleaning unit 6 is rotated to rub the lower cleaning surface of the cleaning member 3 against the dressing member 15. At the same time, water is supplied from the cleaning liquid nozzle 16 to the region where the cleaning member 3

contacts the dressing member 15, for thereby carrying out a self-cleaning of the cleaning member 3.

The dressing member 15 with the layer 15b of diamond pellets electrodeposited on the base plate 15a is capable of generating a new cleaning surface of the cleaning member 3 by both scraping a contaminated surface layer off the cleaning member 3 and mechanically abrading a contaminant attached to the cleaning surface of the cleaning member 3, thus creating a fresh cleaning surface thereon. These scraping and mechanically abrading actions depend on the magnitude of the pressure under which the cleaning member 3 is pressed against the dressing member 15, and the surface roughness of the dressing member 15.

Since the cleaning apparatus has a mechanism for controlling the pressure under which the cleaning member 3 is pressed against the semiconductor substrate 1, the mechanism may be used to control the pressure under which the cleaning member 3 is pressed against the dressing member 15.

FIG. 4 shows another self-cleaning unit 19 which can be used in the cleaning apparatus shown in FIG. 1. As shown in FIG. 4, the self-cleaning unit 19 has a cleaning cup 17 mounted on the upper end of the support shaft 13. The cleaning cup 17 has a flat bottom supporting thereon the dressing member 15 which comprises the layer 15b of diamond pellets electrodeposited on the base plate 15a. The self-cleaning unit 19 which is incorporated in the cleaning apparatus shown in FIG. 1 operates as follows: Water is supplied to the cleaning cup 17 from the cleaning liquid nozzle 16 so as to overflow the cleaning cup 17, and simultaneously the cleaning member 3 of the cleaning unit 6 is rubbed against the dressing member 15. When the self-cleaning of the cleaning member 3 is finished, the cleaning member 3 is lifted slightly off the dressing member 15 and kept in the water contained in the cleaning cup 17. In this manner, the cleaning member 3 can be stored in place without being dried. The cleaning member 3 is prevented from being dried in order to prevent the contaminant attached to the cleaning member 3 from adhering strongly to the cleaning member 3.

FIG. 5 shows in perspective a cleaning apparatus according to a second embodiment of the present invention.

As shown in FIG. 5, the cleaning apparatus comprises a spin chuck 2 for holding and rotating a semiconductor substrate 1, a cylindrical cleaning roller 21 rotatable about an axis parallel to the upper surface, to be cleaned, of the semiconductor substrate 1, a cleaning liquid nozzle 23 for supplying a cleaning liquid onto the upper surface of the semiconductor substrate 1, and a cleaning cup 24 positioned in a retracted position spaced from the spin chuck 2, for cleaning a cleaning member on the cleaning roller 21 after it has cleaned the semiconductor substrate 1.

The spin chuck 2 comprises a plurality of fixed spindles 26 and a plurality of rolls 27 rotatably mounted on the respective upper ends of the spindles 26 for holding the outer circumferential edge of the semiconductor substrate 1. The semiconductor substrate 1 is rotated by rotational forces transmitted from the rolls 27 to the outer circumferential edge of the semiconductor substrate 1. A cleaning member 22 is wound around the cleaning roller 21. The cleaning member 22 comprises a layer of PVA sponge. The cleaning roller 21 is supported in a cantilevered fashion by a support column 28 which is movable in the directions indicated by the arrows X and Z in FIG. 5.

The semiconductor substrate 1 is transferred to a position over the spin chuck 2 by a robot arm or the like, and held by the spin chuck 2 with its surface, to be cleaned, facing upwardly. The semiconductor substrate 1 is rotated at a predetermined speed by the rolls 27, and simultaneously a cleaning liquid is ejected from the cleaning liquid nozzle 23 toward a substantially central area of the semiconductor substrate 1. All of the rolls 27 are positively rotated at the same speed by a common motor or motors (not shown). If at least one of the rolls 27 were positively rotated and the other rolls 27 were idly rotated in contact with the semiconductor substrate 1, then those other rolls 27 would tend to slip against the semiconductor substrate 1 and be worn due to frictional engagement therewith, thereby producing particles which would contaminate the semiconductor substrate 1.

The support column 28 is moved to transfer the cleaning roller 21 with the cleaning member 22 wound therearound from the cleaning cup 24 in the retracted position to a position over the semiconductor substrate 1, and then lowered to bring the cleaning member 22 into contact with the upper surface of the semiconductor substrate 1. The cleaning roller 21 starts being rotated immediately before it contacts the semiconductor substrate 1.

After scrubbing the semiconductor substrate 1 with the cleaning member 22 for a predetermined period of time, the cleaning roller 21 is lifted off the semiconductor substrate 1 by ascending movement of the support column 28, and the semiconductor substrate 1 is discharged out of the cleaning apparatus. Thereafter, the cleaning member 22 on the cleaning roller 21 is moved by the support column 28 into the cleaning cup 24 as indicated by the dot-and-dash line. The cleaning cup 24 is filled with a cleaning liquid. A quartz plate 29 is attached to the bottom of the cleaning cup 24. The cleaning member 22 is pressed against an upper surface of the quartz plate 29 while the cleaning member 22 is being cleaned by the cleaning liquid in the cleaning cup 24.

FIG. 6 shows the positional relationship between the cleaning member 22 and the quartz plate 29 in the cleaning cup 24. If it is assumed that the distance (radius) from the center of the cleaning roller 21 to the surface of the sponge layer of the cleaning member 22 is represented by R and the distance from the center of the cleaning roller 21 to the upper surface of the quartz plate 29 is represented by L, then the cleaning member

22 is pressed against the quartz plate 29 and the sponge layer of the cleaning member 22 is deformed until the distance L is much shorter than the distance R (L < R). At this time, the cleaning roller 21 is rotated about its own axis.

Since the sponge layer of the cleaning member 22 is elastically deformed (compressed) by the quartz plate 29, the cleaning liquid absorbed by the sponge layer is squeezed out of the sponge layer, thus forcing a contaminant attached to the surface of the sponge layer out of the sponge layer together with the cleaning liquid. This self-cleaning effect acts on the entire surface of the sponge layer because the cleaning roller 21 is rotated.

FIG. 7 shows in an enlarged scale the upper surface of the quartz plate 29. As shown in FIG. 7, the quartz plate 29 has a grid-like pattern of minute grooves 29a which roughen the upper surface of the quartz plate 29. Since the cleaning member 22 is pressed against the rough upper surface of the quartz plate 29 for self-cleaning, the contaminant on the cleaning member 22 is effectively scraped off by the rough upper surface of the quartz plate 29, and hence the self-cleaning effect of the cleaning member 22 is increased. While the minute grooves 29a in the quartz plate 29 may not necessarily be arranged in a grid pattern, they should preferably be patterned in identical shapes over the entire surface of the quartz plate 29.

When the cleaning member 22 which has scrubbed the semiconductor substrate 1 is cleaned in rubbing engagement with the rough upper surface of the quartz plate 29, certain vibrations are imparted to the cleaning member 22 to directly scrape the contaminant off the cleaning member 22. Accordingly, the cleaning member 22 can be cleaned to a high level of cleanliness.

FIG. 8 shows still another self-cleaning unit 30 which can be used in the cleaning apparatus shown in FIG. 1.

As shown in FIG. 8, the self-cleaning unit 30 comprises a brush 32 supported on the upper end of a support shaft 31, and a cleaning liquid nozzle 33 for supplying water to the brush 32. The brush 32 comprises a brush base 32a and a number of nylon bristles 32b upwardly mounted on the brush base 32a.

The self-cleaning unit 30 which is incorporated in the cleaning apparatus shown in FIG. 1 operates as follows: The cleaning member 3 which has scrubbed the semiconductor substrate 1 is moved above the self-cleaning unit 30. The swing arm 7 (see FIG. 1) is then lowered until the cleaning member 3 contacts the bristles 32b, and then the cleaning unit 6 is rotated to clean the cleaning member 3 with the bristles 32b. At the same time, the cleaning liquid nozzle 33 supplies water to the region where the cleaning member 3 is rubbed against the bristles 32b.

Because the cleaning member 3 is held against the brush 32 and moved relatively to the brush 32, a contaminant, particularly particles, attached to the cleaning member 3 when it has scrubbed the semiconductor substrate 1, is removed from the cleaning member 3 by the brush 32.

According to a modification, the brush 32 may be fixed to the bottom of a cleaning cup as shown in FIG. 4, and the cleaning member 3 and the brush 32 may be moved relatively to each other in the water contained in the cleaning cup. If the water is supplied at a rate to overflow the cleaning cup, then since removed particles can be discharged out of the cleaning cup by the overflow of water, the cleaning member 3 can be cleaned highly effectively by self-cleaning.

The structure of the cleaning apparatus, the type of the cleaning member, and the method of self-cleaning may be combined as desired. For example, the abrasive cloth may be attached to the cylindrical roller 21 shown in FIG. 5, and may be cleaned by the brush 32 shown in FIG. 8.

FIG. 9 shows a system composed of a cleaning apparatus according to the present invention which are combined with a polishing apparatus for polishing semiconductor substrates. As shown in FIG. 9, the system comprises a polishing apparatus 40, a substrate storage cassette 50, a feed robot 55, a first cleaning apparatus 60, and a second cleaning apparatus 65.

A polishing step which is carried out by the polishing apparatus 40 is one of the steps of a semiconductor fabrication process, and serves to polish a semiconductor substrate to a flat mirror finish. When interconnections are to be formed as layers on the surface of a semiconductor substrate, the surface of the semiconductor substrate is polished to a flat mirror finish before the layers are deposited, so that the layers will subsequently be formed smoothly on the semiconductor substrate.

FIG. 10 shows the polishing apparatus 40 in detail. As shown in FIG. 10, the polishing apparatus 40 comprises a turntable 41 and a top ring 43 for holding and pressing a semiconductor substrate 1 against the turntable 41. The turntable 41 is coupled to a motor (not shown) and can be rotated about its own axis in the direction indicated by the arrow. A polishing abrasive cloth 44 is applied to the upper surface of the turntable 41 for contact with the semiconductor substrate 1. The polishing abrasive cloth 44 is made of the same material as that of the cleaning member 3 shown in FIGS. 1 and 2.

The top ring 43 is coupled to a motor (not shown) and also to a cylinder (not shown) for vertically moving the top ring 43. Therefore, the top ring 43 can be vertically moved in the directions indicated by the arrows and also can be rotated about its own axis, so that the semiconductor substrate 1 can be pressed against the polishing abrasive cloth 44 under a desired pressure. An abrasive solution nozzle 45 is positioned over the turntable 41 for supplying an abrasive solution Q onto the polishing abrasive cloth 44 attached to the upper surface of the turntable 41.

In operation, a semiconductor substrate 1 to be polished is taken out from the substrate storage cassette 50, reversed to face a surface to be polished down-

wardly, and then conveyed to the polishing apparatus 40 by the feed robot 55. In the polishing apparatus 40, the semiconductor substrate 1 is supported on the lower surface of the top ring 43, and then pressed against the polishing abrasive cloth 44 on the upper surface of the rotating turntable 41 while the semiconductor substrate 1 is being rotated by the top ring 43. The abrasive solution Q is supplied from the abrasive solution nozzle 45 onto the polishing abrasive cloth 44. The lower surface of the semiconductor substrate 1 is thus polished by the polishing abrasive cloth 44 with the abrasive solution Q existing between the lower surface of the semiconductor substrate 1 and the polishing abrasive cloth 44.

After having been polished, the semiconductor substrate 1 carries on its surface abrasive grain contained in the abrasive solution Q and ground-off particles of the semiconductor substrate 1, and is contaminated by an alkaline metal of potassium (K) because the abrasive solution is of an alkaline base. These abrasive grain, particles, and contaminant have to be cleaned away subsequently.

As shown in FIG. 9, the polished semiconductor substrate 1 is turned upside down to make the polished surface upper side and conveyed by the feed robot 55 to the first cleaning apparatus 60 in which the semiconductor substrate 1 is scrubbed by a brush to remove most of the abrasive grain, particles, and contaminants from the surface of the semiconductor substrate 1.

After the semiconductor substrate 1 has been cleaned by the cleaning apparatus 60, the semiconductor substrate 1 is fed to the second cleaning apparatus 65 before the surface of the semiconductor substrate 1 is dried. In the second cleaning apparatus 60, the semiconductor substrate 1 is scrubbed by the cleaning member 3 shown in FIGS. 1 and 2 to remove minute particles or submicron particles from the surface of the semiconductor substrate 1 in the manner described above.

As shown in FIGS. 1 and 2, after having cleaned the semiconductor substrate 1, the cleaning unit 6 is moved to the self-cleaning unit 9, and presses the cleaning member 3 against the dressing member 15 under a predetermined pressure. The swing arm 7 is swung and the cleaning unit 6 is rotated to rub the lower cleaning surface of the cleaning member 3 against the dressing member 15. At the same time, water is supplied from the cleaning liquid nozzle 16 to the region where the cleaning member 3 contacts the dressing member 15, for thereby carrying out a self-cleaning of the cleaning member 3.

The cleaning method according to the present invention has been described above in combination with the polishing step. However, the cleaning method according to the present invention may be any of various steps of the semiconductor fabrication process, e.g., an etching step or a chemical vapor deposition (CVD) step.

As described above, according to the present invention, the cleaning member which is contaminated by cleaning the workpiece can be cleaned to a high level of cleanliness by carrying out a self-cleaning of the cleaning member, and hence the cleaning effect of the workpiece is enhanced. Further, a service life of the cleaning member is prolonged, and the processing capability of the cleaning apparatus is increased.

Although certain preferred embodiments of the present invention have been shown and described in detail, it should be understood that various changes and modifications may be made therein without departing from the scope of the appended claims.

Claims

1. A method of cleaning a workpiece, comprising the steps of:

   holding a workpiece;
   scrubbing the workpiece with a cleaning member; and
   rubbing said cleaning member against a member having a rough surface to carry out a self-cleaning of said cleaning member.

2. A method according to claim 1, wherein said cleaning member comprises an abrasive cloth having micropores in a cleaning surface thereof which is held in contact with the workpiece.

3. A method according to claim 1, wherein said cleaning member comprises a sponge.

4. A method according to claim 1, wherein said self-cleaning of said cleaning member is carried out by rubbing said cleaning member against a surface having diamond pellets thereon.

5. A method according to claim 1, wherein said self-cleaning of said cleaning member is carried out by rubbing said cleaning member against a surface having minute grooves.

6. A method of cleaning a workpiece, comprising the steps of:

   holding a workpiece;
   scrubbing the workpiece with a cleaning member made of an abrasive cloth; and
   bringing the cleaning member into contact with a brush to carry out a self-cleaning of said cleaning member.

7. A method of cleaning a workpiece, comprising the steps of:

   holding a workpiece;
   scrubbing the workpiece with a cleaning member made of sponge;
   immersing said cleaning member in a cleaning

liquid in a cleaning cup; and

pressing said cleaning member against a flat portion in said cleaning cup until said cleaning member is elastically deformed by said flat portion.

8. An apparatus for cleaning a workpiece, comprising:

a holding unit for holding a workpiece;
a cleaning unit movable relatively to the workpiece;
a cleaning member provided on said cleaning unit for scrubbing the workpiece; and
a flat portion having a rough surface for contacting said cleaning member to carry out a self-cleaning of said cleaning member.

9. An apparatus according to claim 8, further comprising a cleaning liquid nozzle for supplying a cleaning liquid to said cleaning member.

10. An apparatus according to claim 8, wherein said cleaning member comprises an abrasive cloth having micropores in a cleaning surface thereof which is held in contact with the workpiece.

11. An apparatus according to claim 8, wherein said cleaning member comprises a sponge.

12. An apparatus according to claim 8, wherein said flat portion comprises a flat plate having diamond pellets thereon.

13. An apparatus according to claim 8, wherein said flat portion comprises a flat plate having a surface with minute grooves.

14. An apparatus according to claim 8, wherein said cleaning unit comprises one of a cleaning unit rotatable about an axis perpendicular to a surface, to be cleaned, of the workpiece and a cylindrical cleaning unit rotatable about an axis parallel to a surface, to be cleaned, of the workpiece.

15. An apparatus for cleaning a workpiece, comprising:

a holding unit for holding a workpiece;
a cleaning unit movable relatively to the workpiece;
a cleaning member provided on said cleaning unit for scrubbing the workpiece; and
a brush for contacting said cleaning member to carry out a self-cleaning of said cleaning member.

16. An apparatus according to claim 15, further comprising a cleaning liquid nozzle for supplying a cleaning liquid to said cleaning member.

17. An apparatus for cleaning a workpiece, comprising:

a holding unit for holding a workpiece;
a cleaning unit movable relatively to the workpiece;
a cleaning member made of sponge provided on said cleaning unit for scrubbing the workpiece;
a cleaning cup disposed in a retracted position of said cleaning unit and filled with a cleaning liquid for immersing said cleaning member therein, said cleaning cup having a flat portion for contacting said cleaning member; and
a mechanism for pressing said cleaning member against said flat portion until said cleaning member is elastically deformed.

18. An apparatus according to claim 17, wherein said flat portion comprises a quartz plate.

FIG. 1

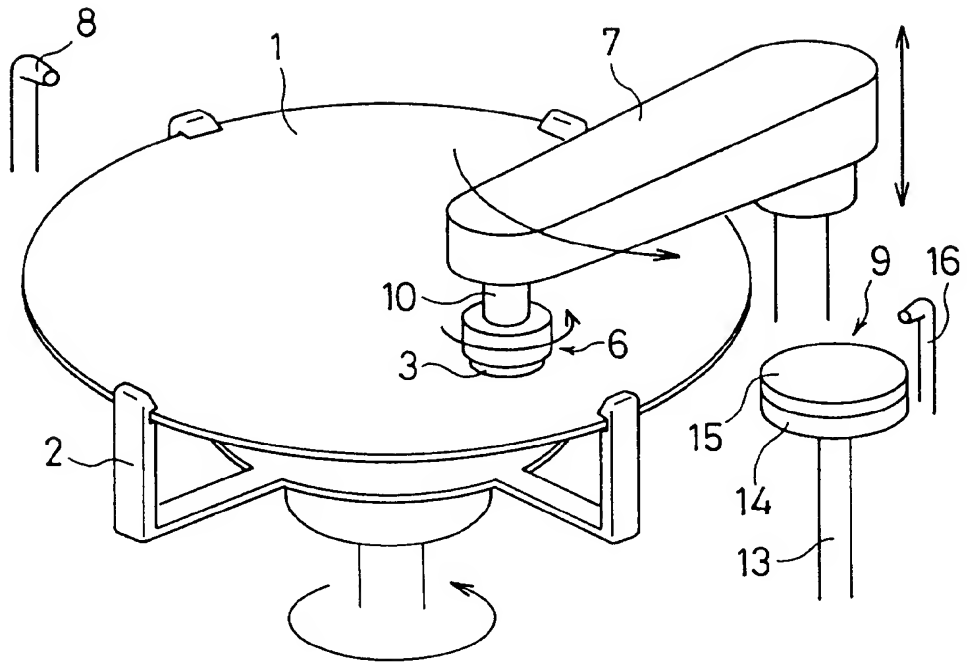


FIG. 2

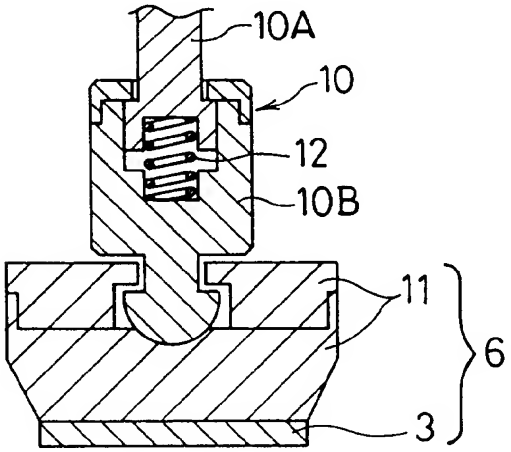


FIG. 3

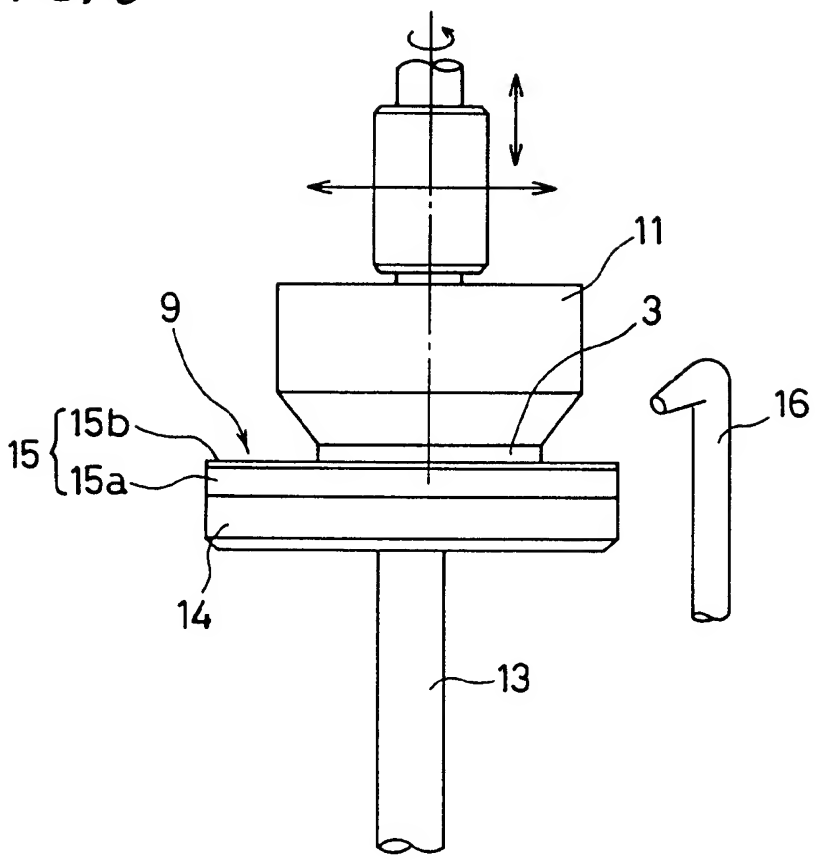
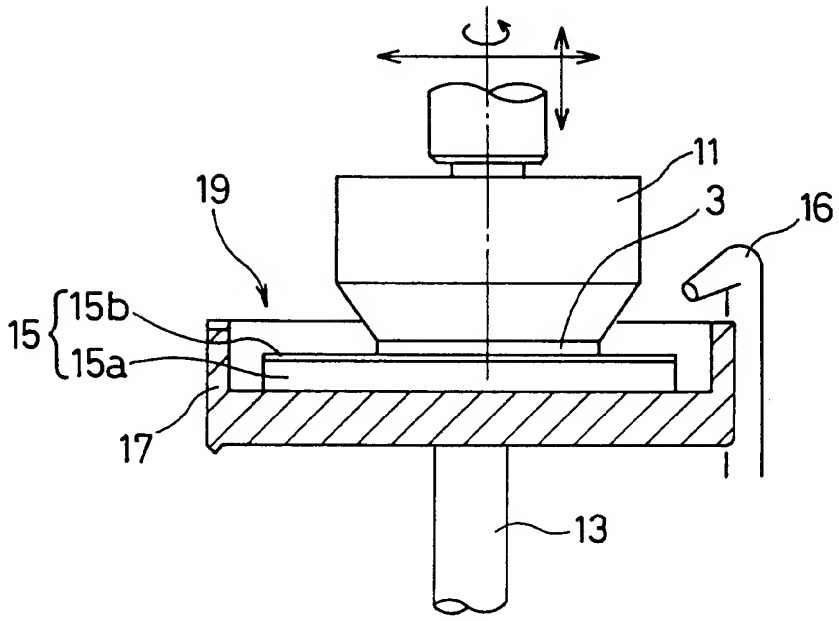


FIG. 4



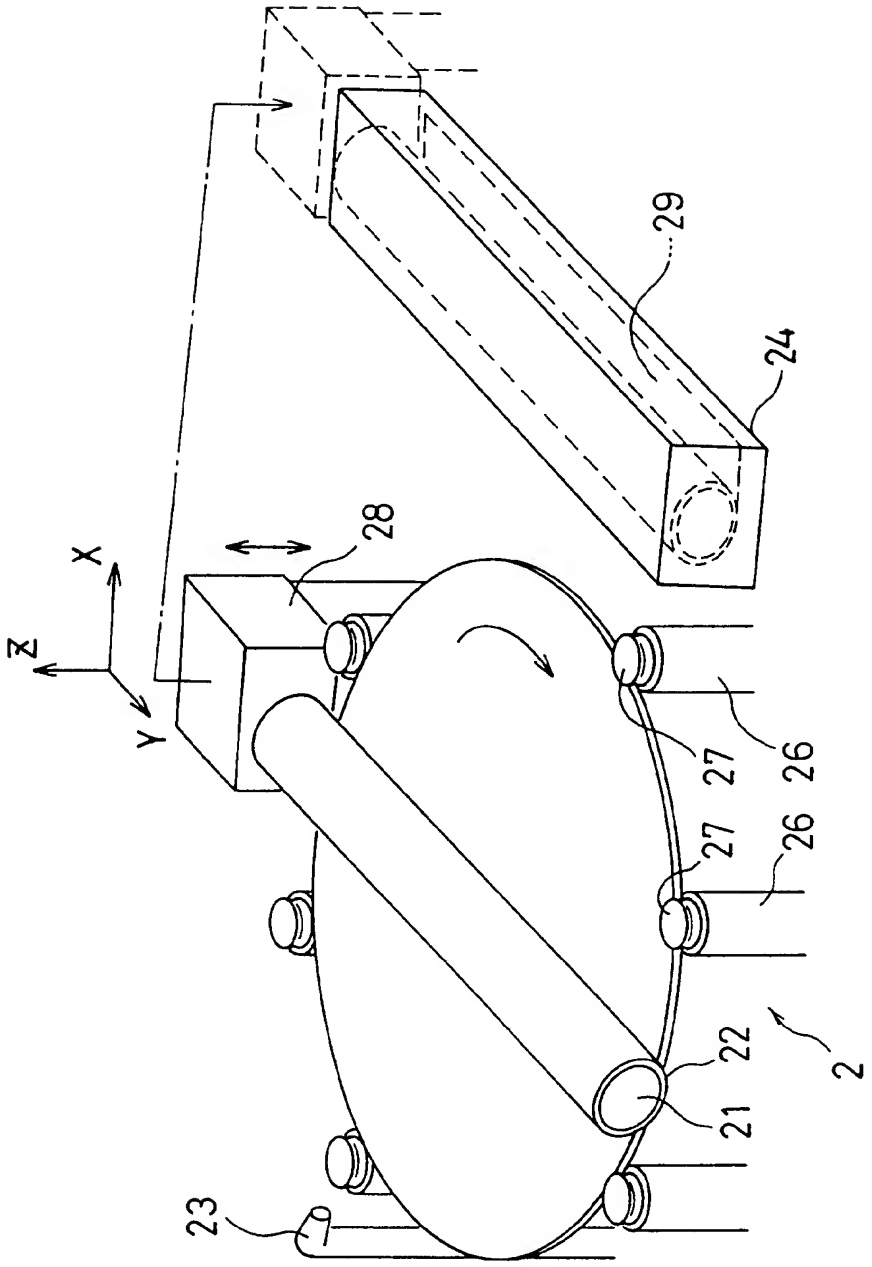


FIG. 5

FIG. 6

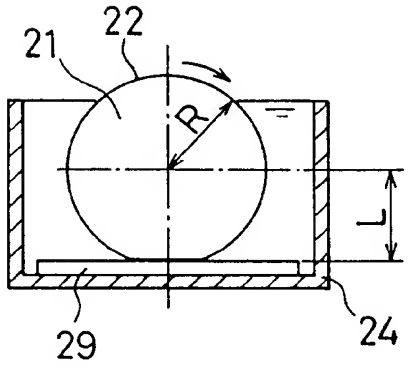


FIG. 7

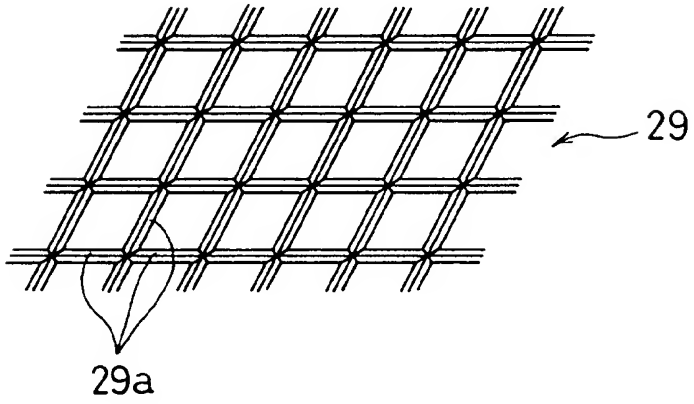
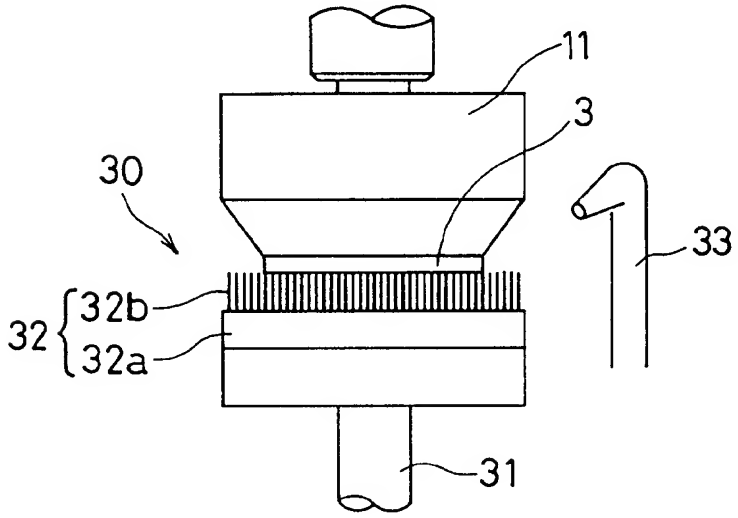


FIG. 8



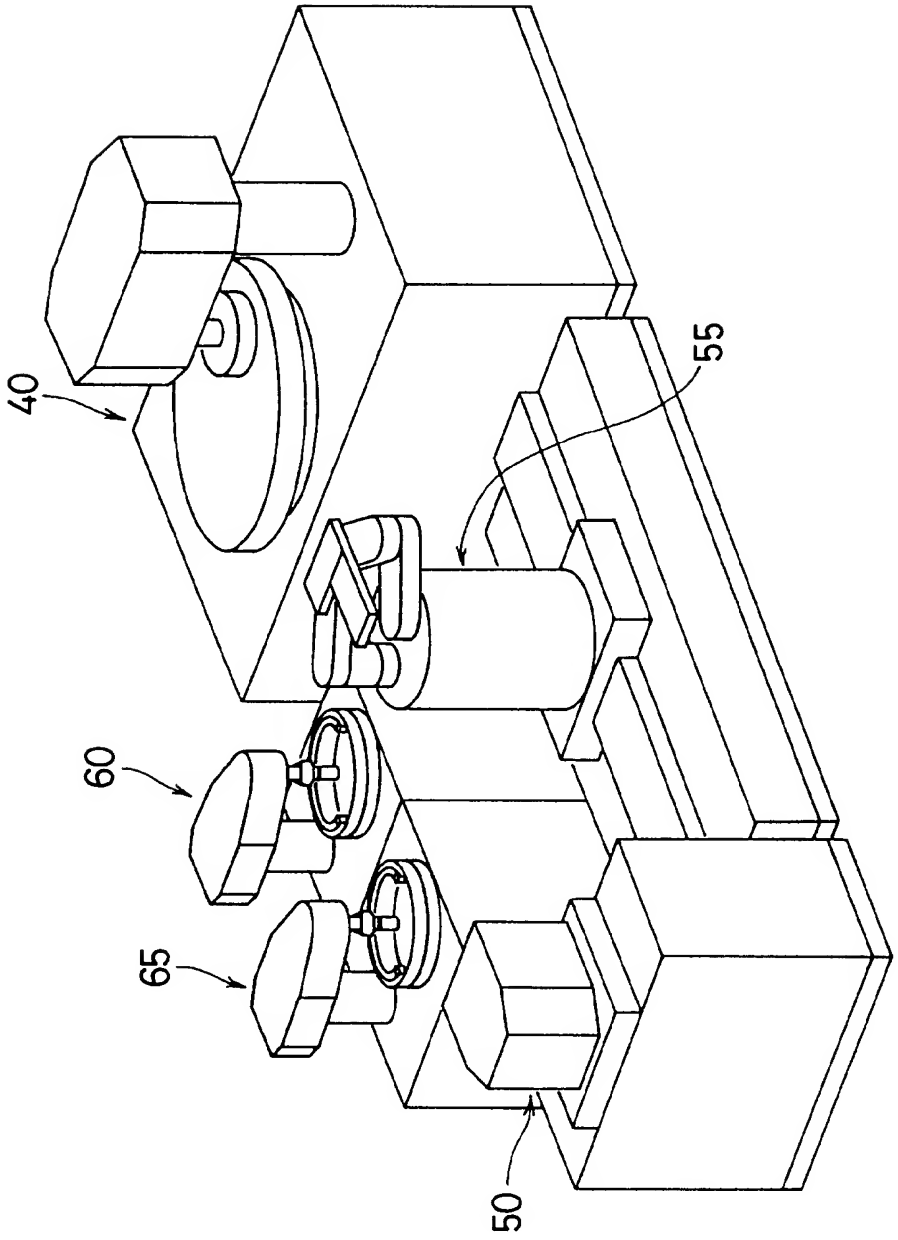
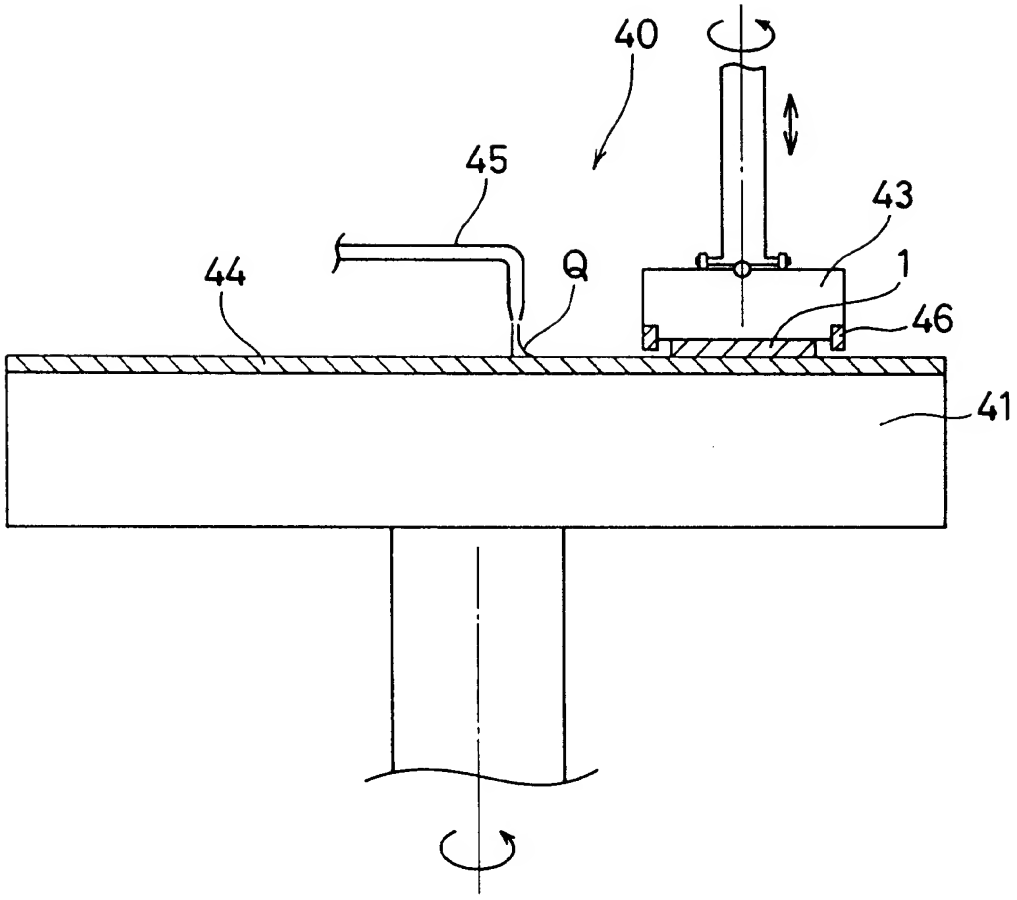


FIG. 9

FIG. 10



European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 11 5046

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	PATENT ABSTRACTS OF JAPAN vol. 10, no. 99 (E-396) [2156] , 16 April 1986 & JP-A-60 240129 (FUJITSU K.K.), 29 November 1985, * abstract *	1,15,16	B08B1/04
A		6,8,9,14	

A	US-A-5 375 291 (TATEYAMA ET AL) * column 1, line 7 - line 11 * * column 3, line 62 - column 4, line 15 * * column 7, line 1 - line 27; figures 2,9 *	1,6-9, 14-17	

A	US-A-4 476 601 (OKA) * column 1, line 5 - line 31; figure 1 *	1,6-8, 14,15,17	

A	US-A-5 311 634 (ANDROS) * abstract *	1,3,7,17	
	---		TECHNICAL FIELDS SEARCHED (Int.Cl.6)
X	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 38, no. 6, June 1995, NEW YORK US, pages 527-528, XP000520759 "CMP Pad Conditioner for Nonplanar Polishing Pads" * the whole document *	1,2,6, 15,16	B08B B24B H01L
A		8-10	

X	WO-A-95 18697 (SPEEDFAM CORP.) * page 1, line 2 - line 9 * * page 4, line 11 - page 5, line 11; figures *	1,4,8,9, 12	
A		2,5,10, 15,16	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 January 1997	Van der Zee, W

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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